SERVICE INSTRUCTIONS

148-032

800

section DC

DIGIT - INSERTION UNIT _ DI-4

P/N 1163-4000
(Used only is the Type 1163 Synthesizers)

TABLE OF CONTENTS

Section DC-1 INTRODUCTION ____ DC-3

DC-1.1 General ____ DC-3
DC-1.2 Purpose ____ DC-3
DC-1.3 Description ____ DC-4

Section DC-2 PRINCIPLES OF OPERATION ____ DC-5

DC-2.1 General ____ DC-5
DC-2.2 Pulse Generator ____ DC-6
DC-2.3 Digit Oscillator ____ DC-6
DC-2.4 Amplifier Circuit ____ DC-7
DC-2.5 Sampler and Dc Amplifier System ____ DC-7
DC-2.6 Recapitulation—Oscillator Control Loop ____ DC-8
DC-2.7 Lamp-Control Circuit ____ DC-8

Section DC-3 SERVICE AND MAINTENANCE ____ DC-9

DC-3.1 Introduction ____ DC-9
DC-3.2 Test Equipment ____ DC-9
DC-3.3 Trouble Analysis ____ DC-10
DC-3.4 Dc Voltage Checks ____ DC-13
DC-3.5 Repairs and Replacement ____ DC-13

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GENERAL RADIO COMPANY

West Concord, Massachusetts

SECTION DC-1

INTRODUCTION

DC-1.1 GENERAL.

The information contained in this section supplements the over-all operation and instrument-maintenance instructions that appear in the front of this manual. This section is prepared with a modular point of view. It is intended to furnish detailed information necessary for proper field maintenance (in the event of module failure), as indicated by paragraph 5.6 "System Trouble-Analysis".

Included in the following paragraphs are a physical description and signal-flow discussion of the module sufficient for comprehension, by experienced service personnel, of the principles of operation. A trouble-analysis procedure that will aid in isolating the defective circuit completes the section.

To facilitate part identification, reference designators used in the text and on the photographs are the same as those that appear on the complete schemetic diagram and in the parts list. The reference designators are silk-screened on the module as a further aid in part location.

The service instructions are written to facilitate use of a properly functioning synthesizer as a basic test frame for the module. The instrument can be used to support the module, in a convenient bench-service position, and to supply it with power and test signals.

NOTE

First consideration should be given to the use of the widespread General Radio Company service organization to repair a defective module, particularly on an instrument still within the two-year warranty coverage.

DC-1.2 PURPOSE.

The DI-4 Digit-Insertion unit is employed in the General Radio Type 1163 12-Mc Coherent Decade-Frequency Synthesizer to furnish the dial-selected 1-Mc steps in the instrument output. It differs completely in function and electrical design from other Digit-Insertion units in the instrument and, although of a very similar mechanical configuration, is not interchangeable with other types of Digit-Insertion units. Mounting arrangements in the chassis are identical with those for the other digit units, comprised of two screws through the front panel to the top of the unit and a hold-down clamp at the rear. (For a description of the DI-1 module, the digit unit repetitively used for all steps in the Type 1161 and 1162 synthesizers, and for all steps but x 1 Mc/s in the Type 1163, refer to Section DA of this manual.)

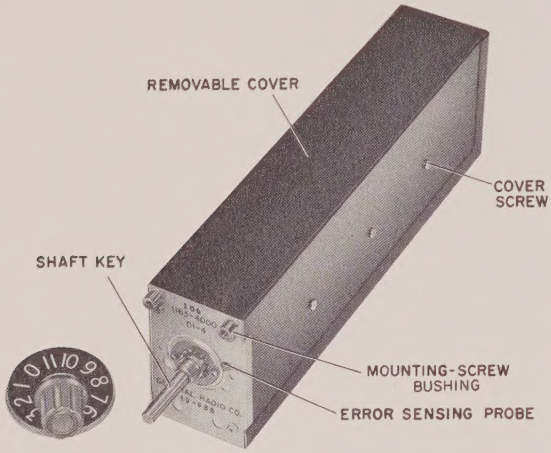


Figure DC-1.
DI-4 Digit-Insertion unit module.

DC-1.3 DESCRIPTION.

DC-1.3.1 MECHANICAL LAYOUT.

The mechanical layout of the DI-4 module is very similar to that of the DI-1 unit and consists of an assembly of four etched boards,which contains all of the electrical components that form the DI-4 circuitry.

Sheet-metal rails, on the long edges of the two larger circuit boards, run the length of the unit. Threaded inserts on these rails fasten the entire assembly. A central sheet-metal shield provides electrical isolation and additional mechanical support for the structure. Spool inserts in the edge of this shield plate serve as anchor points for the module cover.

The front of the unit consists of an etched-circuit board and structural parts. This front etched-circuit board carries the dial-lamp control circuitry. A pin on the board projects through the front of the module (see Figure DC-1) to establish electrical contact with the DI-4 dial-lamp control spring on the chassis front panel. A plate in front of this etched board carries the digit-selector switch detent mechanism. Spring contacts of finger stock around the perimeter of the front panel make a tight electrical seal with the mouth of the outer cover.

The rear of the module consists of a vertical etched board which carries the Digit Oscillator (see paragraph DC-2.3) and the rotary switch wafers operated by the front-panel control. The switch wafers and twelve tuning coils are mounted on a separate plate, on posts from the vertical etched board, that are positioned in such a way that the oscillator tuning adjustments are all accessible from the rear.

CAUTION

These are not intended for field adjustment.

The switch shaft runs the entire length of the module, just above the center shield partition.

The bottom board of the assembly carries three jacks and two ground-pickup pins, which engage contacts and banana plugs projecting from the sandwich deck.

A removable sheet-metal cover, which slides over the back of the unit, encloses the module on five sides. The cover is secured with six 4-40 screws, three per side. The cover, in addition to mechanical support and protection, provides electrical shielding for the more sensitive circuits in the module. Alignment of the unit is affected considerably by the presence or absence of this cover; consequently, the cover must be in place if the module is to function properly.

Interconnection between the etched boards is made, with two exceptions, by connection of wire links at the edges of the boards. The two exceptions are a twisted pair of wires (from top to bottom) at the front of the unit and the miniature coaxial cable, near the center, that passes through a hole in the center shield partition.

DC-1.3.2 ELECTRICAL CHARACTERISTICS.

Circuits are divided functionally at the circuit-board level, making component locations largely self-explanatory.

The DI-4 unit supplies signal outputs, frequency coherent with the master quartz oscillator in the AFS unit, necessary to produce the 1-Mc digit steps in the Type 1163 synthesizer. The function of this module in the operation of the Type 1163 system, described more fully in Section 4 of the front portion of this manual, consists of the subtraction (from the multiplied output of the DI-1 units (at 50-51 Mc/s), of frequencies in 1-Mc steps from 50 to 39 Mc/s, to obtain the 0-12-Mc output frequency. Table DC-1 gives the output frequency from the Type 1163 for each of the dial settings available.

To form the 12 frequency steps (50 to 39-Mc steps) coherently from the master crystal oscillator, the DI-4 accepts as an input, a 1-Mc sine-wave from the sandwich deck. The 1-Mc signal is generated in the AFS unit, by frequency division from the 5-Mc crystal oscillator (refer to Section CA of this manual). This 1-Mc input to the DI-4 is used as the reference to phase-lock an oscillator, which has been rough-tuned by the dial switch, to any one of the desired 50 to 39-Mc output frequencies of the DI-4. This principle is discussed more fully in Section DC-2.

The other external connections for the DI-4 consist of the +18-volt No. 1 input from the power supply and the external lamp-control pin. The lamp-control circuit is so arranged that, if the digit oscillator fails to lock, the lamp-control pin is de-energized and extinguishes the lamp in the lamp-control assembly on the front panel, to give warning of failure.

SECTION DC-2

PRINCIPLES OF OPERATION

DC-2.1 GENERAL

In this section, reference is made to the elementary schematic diagram, Figure DC-2, and the complete schematic diagram, Figure DC-14.

The principal circuit in the DI-4 is a sampled-data, automatic phase-control system which uses 1 Mc/s as a reference signal to lock a rough-tuned oscillator to a multiple of 1 Mc/s, chosen in the band of frequencies from 39 to 50 Mc/s.

The 1-Mc sine-wave input is converted to a short-duration, high-peak-power pulse with a 1-Mc repetition rate. This pulse is used to operate a gate connected to the output of the digit oscillator which, when opened by the pulse, connects the output of the oscillator to a holding capacitor that stores the instantaneous value of the oscillator output voltage when the sampling pulse occurs. If the oscillator is tuned exactly to an integer multiple of the 1-Mc input, the value of the sample is the same each time and the voltage on the holding capacitor is dc. If there is a difference between the oscillator frequency and the corresponding multiple of the 1-Mc input reference, a stepwise sinewave signal results, which represents the drift between the oscillator and the closest multiple of the 1-Mc reference. The amplified holding-capacitor voltage is used as an error signal to phase-lock the oscillator. Figure DC-3 shows the nature of this error signal.

Since an ac component of error signal is present only when the oscillator is not locked, it can be used to indicate malfunction. In the DI-4, the error

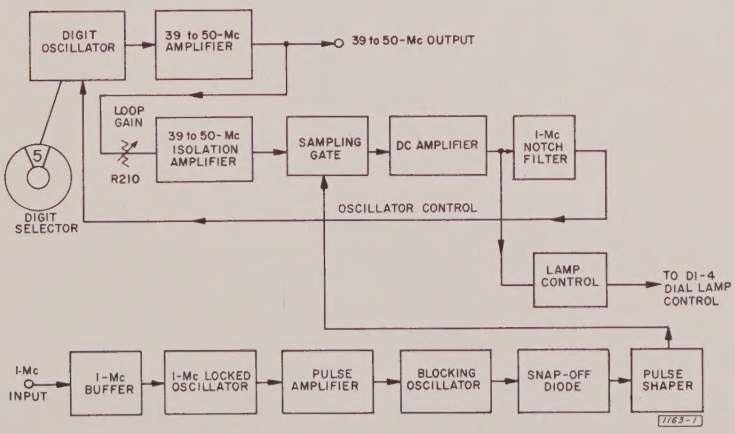
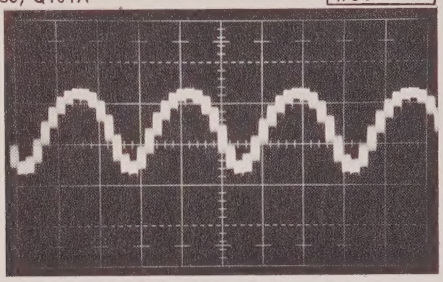


Figure DC-2. DI-4 Block diagram.

Base, Q101A 1160-G-27



0.05 V/cm 5.0 μs/cm

Figure DC-3. Step-wise sinewave signal at the base of Q101A indicative of the operation of the sampler circuit in response to oscillator drift.

signal is sensed for presence of ac and, if ac is found, the dial lamp is extinguished (refer to paragraph DC-2.7).

The operating principles of individual circuits are discussed in more detail below.

DC-2.2 PULSE GENERATOR.

The 1-Mc input enters the DI-4 via J203. From this point, it is fed to a tuned isolation amplifier (Q204/T204) located at the front of the unit on the bottom board. The output link on T204 connects (via AT203 and AT204) to a 1-Mc injection-locked oscillator on the front of the top board.

This oscillator is comprised of Q103/Q104 and tuned-circuit elements C111, C112 and L106. The oscillator active element is an emitter-coupled transistor pair operating as a switch. In operation the transistors are turned on alternately, with a resulting square-wave of current in each collector. The tuned-circuit filters the square-wave current in the collector of Q103, and this voltage is tapped to the Q104 base, via C113, to close the loop on the oscillator.

The injected 1-Mc signal from T204 is fed in series with the base of Q103. The collector current of Q104 drives an inductor, L107. Inductor L107 rings at its self-resonant frequency for one-half cycle; CR105 clamps the next half cycle to dissipate the remainder of the energy in the inductor.

The resulting pulse is amplified in Q105 and another self-resonant choke, L108, shortens the spike further. This spike triggers the monostable blocking oscillator Q106/T102, and the blocking oscillator cycles once for each pulse received from Q105. The amplitude of the blocking oscillator is controlled by R128. Waveforms of these various parts of the circuit can be seen in Figure DC-6.

The load for the blocking oscillator consists of R127 and a snap-off diode, CR106, at the end of a coaxial delay line, Z101. When the blocking oscillator turns on negatively, CR106 turns on also, since its anode is effectively grounded for low frequencies, through delay lines Z102 and Z104. While it is conducting, a certain amount of charge is stored in the diode junction so that, when the blocking oscillator turns off abruptly, the diode retains its high conductance (because of the mobile carriers in its junction) until the charge is swept out. Then, as the stored charge is abruptly exhausted, the diode turns off in a small fraction of a nanosecond.

This sharp transition creates a negative pulse at the anode of CR106, which propagates down Z102 until it reaches the junction of Z102, Z103, and Z104. The reflection of this pulse, from the end of shorted clipping line Z104, returns to the junction of the three delay lines with reversed phase, canceling the input. The electrical length of Z104 thus determines the width of the pulse. The pulse travels down Z103 to the sampling gate.

Delay lines Z101 to Z104 consist of the four sections of preformed, semirigid, 50-ohm coaxial cable mounted on the top board.

DC-2.3 DIGIT OSCILLATOR.

The Digit Oscillator assembly is mounted at the rear of the DI-4 module. The circuit contains one transistor, Q401, connected as a Colpitts oscillator with the base at rf ground.

Manual tuning is accomplished by switch selection of one of the 12 preset coils, L403 to L414. The

TABLE DC-1

TYPE 1163 SYNTHESIZER OUTPUT-FREQUENCY RANGES FOR DI-4 DIAL SETTINGS (Figure DC-5 and DC-14)

Synthesizer Range (Mc/s)	*DI-4 Dial Setting*	*DI-4 fout (Mc/s)*	*DI-4 Switch Position (S401)*	*Tuned by Coil*
0-1	0	50	110F 210F	L403
1-2	1	49	111F 211F	L404
2-3	2	48	112F 212F	L405
3-4	3	47	101F 201F	L406
4-5	4	46	102F 202F	L407
5-6	5	45	103F 203F	L408
6-7	6	44	104F 204F	L409
7-8	7	43	105F 205F	L410
8-9	8	42	106F 206F	L411
9-10	9	41	107F 207F	L412
10-11	10	40	108F 208F	L413
11-12	11	39	109F 209F	L414

appropriate coil is selected by S401, the only operating control on the module. The 12 coils are tuned to the frequencies shown on Table DC-1. The 2-section 12-position rotary switch and the 12 coils surrounding it are mounted on the aluminum plate at the rear of the module.

The oscillator is also voltage-tunable (at AT404) by means of a dc voltage applied to varactor diodes CR401 and CR402. These diodes are in parallel for dc, since their cathodes are tied directly together and both anodes are grounded, one directly, the other through the oscillator coil. For the rf signal, however, the diodes are in series, since the rf appears across the oscillator coil; the voltage-variable capacitance represented by the two varactors in series is also across the oscillator coil and thus across the oscillating circuit.

As the dc voltage from AT404 to ground changes, the oscillator frequency changes correspondingly due to the action of the varactors. Dc power (+18 volts) enters this assembly at AT401, and a through connection feeds this B+ to the remainder of the DI-4 circuits, via AT405.

The rf output from the Digit Oscillator is taken from T401 a 3:1 stepdown, wide-band, toroid transformer in the collector circuit of Q401. This voltage is brought out to the bottom of the oscillator-circuit assembly at AT403 and is fed to the bottom board, where it drives the two high-frequency rf amplifiers described in paragraph DC-2.4.

DC-2.4 AMPLIFIER CIRCUIT.

The bottom board contains three amplifiers, one at 1-Mc, and two at the digit-oscillator frequency. The 1-Mc input amplifier, Q204, is a common-emitter amplifier with tuned output. It is driven by 1 Mc/s entering from the sandwich deck at J203. The tuned output transformer of this stage (T204), supplies 1 Mc/s to the top etched-circuit assembly via a twisted pair of leads from a coupling link on the coil connected to AT203 and AT204.

The second amplifier, Q203, is a broadband amplifier fed by the digit oscillator at AT205, that produces the signal required at the DI-4 output (J202). It also drives the isolation amplifier, Q202 and Q201, which feeds the phase-locking servo system.

The 39-to-50-Mc output leaves the DI-4 via J202 and a ground pin. A spring on the chassis picks up this ground pin when the DI-4 is inserted in its chassis. The Q203 amplifier is a common-base stage with 2:1 stepdown transformer output. The transformer is in transmission-line form, wound on a toroid to achieve broadband characteristics. The input and output impedance of the circuit are similar, and the amplifier has 6 dB of power gain. An adjustable input attenuator, R218, controls the drive to this stage and thereby the output signal level at J202.

The third amplifier on the bottom board consists of two stages, similar to the one described in the preceding paragraph, comprised of Q202 and Q201 and their associated transformers, T202 and T201. An attenuator pad with one adjustable arm regulates the drive to this two-stage amplifier from the output of the Q203 amplifier. The purposes of this two-stage amplifier are to provide the drive signal to the sampler as part of the oscillator locking system, and to keep spurious frequency components, due to imbalances in the sampler, from appearing at the output jack. The ratio of forward-to-reverse gain of this stage is about 70 dB.

The output level of this amplifier determines the output level of the sampler; thus, adjustment of the drive to this stage from R210 controls the loop gain of the phase-lock servo system.

DC-2.5 SAMPLER AND DC AMPLIFIER SYSTEM.

DC-2.5.1 GENERAL.

The top board of the DI-4 contains the balance of the circuitry in the servo loop, including the pulse generator described in paragraph DC-2.2. The remainder of the circuits in the system include the sampler and dc control amplifier, described in the following paragraphs.

DC-2.5.2 SAMPLER.

The sampler is a normally closed gate circuit. This gate is "opened" on command from the 1-Mc repetition-rate pulse from the pulse generator described in paragraph DC-2.2. The gate remains open only for the duration of the pulse, 1 nanosecond. When the gate is open, the impedance between AT107 and the top of C105 is very low; otherwise it is very high.

The gating function is performed by the two high-speed sampling diodes, CR101 and CR102. The circuit is arranged so that the diodes are normally back biased by the voltage divider, R101, R102 and R103. A sampling pulse advancing down Z103 is converted by T103 to balanced drive for the sampler. The current in this pulse turns the diodes on through C101 and C102. The self-inductance of T101 prevents the transformer from short circuiting this very short-duration pulse. The digit-oscillator signal, however, fed in parallel to the windings of T101, appears directly on capacitors C101 and C102. Thus, when CR101 and CR102 conduct, the path through these diodes in parallel is the primary circuit between AT101 (the feedpoint for the rf) and C105, the sample-hold capacitor. C105 therefore charges very rapidly to the instantaneous rf level.

When the gate is closed, holding capacitor C105 is thus left with a charge proportional to the instantaneous level of the rf at AT101, at the time the last sample was taken. C105, when the gate is closed, is loaded only by a very high impedance determined by the Q101 bias current and the reverse leakage current through the diodes; it therefore discharges very slowly. The dc component of current in these two discharging loads is cancelled by a current fed to this point of the circuit by R104, a 10-ohm resistor. This current is determined by the setting of R105, which is adjusted so that the value of the sample charge in C105 (and the voltage across C105) is retained with minimum change, until replaced by the next sample, 1 μs later.

DC-2.5.3 DC AMPLIFIERS.

The dc amplifier in the servo loop consists of Q101, a differential-amplifier transistor pair in a single case, and Q102. The over-all voltage gain with feedback is about 3 and is designed for zero offset and minimum drift. This amplifier provides a low source impedance for the low-pass filter in the oscillator-control circuit, minimum loading on C105, and additional loop gain.

A 1-Mc notch filter (consisting of L104, C107 and L105, C108) is in series with the control line of the oscillator, so that any 1-Mc component appearing at the output of the dc amplifier does not appear at the digit-oscillator control input. Such a signal, if present, would create 1-Mc fm sidebands on the output of the DI-4.

DC-2.6 RECAPITULATION – OSCILLATOR CONTROL LOOP.

In the preceding paragraphs, the individual parts of the oscillator locking system have been described. These elements make up the oscillator locking scheme, to maintain the selected frequency outputs of the DI-4 at strict multiples of the incoming 1-Mc signal.

In review, the rf output of the digit oscillator is sampled at a 1-Mc rate controlled by the 1-Mc input. If the frequency of the digit oscillator is exactly 50 times the input signal (1-Mc), exactly 50 cycles of the 50 Mc/s will occur between samples and the value of the sample will be exactly the same each time. Its value will depend on the phase and amplitude of the 50-Mc signal. Likewise, if the rf is exactly 49 Mc/s, 49 cycles will occur between samples and the value at the instant each sampling pulse occurs will again be the same as at the previous one. The output of the sampler, since the sample is "held" by C105, will therefore be dc, if the frequency is any exact multiple of the 1-Mc sampling rate. Thus, the sampling system can make no distinction as to which multiple is being observed, only that it is, in fact, a multiple of the sampling rate.

If however the rf is not exactly a multiple of the 1-Mc input, each sample will see a different phase of the rf than it saw previously and the result will be a stepwise sinewave with a frequency equal to the amount the rf differs from the closest multiple of 1 Mc/s. This statement holds regardless of which multiple is being dealt with (see Figure DC-3).

The output of the dc amplifier is connected to the digit-oscillator varactors, CR401 and CR402, (via AT108) and corrects the digit-oscillator frequency as required to establish the integral relationship of this frequency to 1 Mc/s, at a multiple as chosen by the position of switch S401.

DC-2.7 LAMP-CONTROL CIRCUIT.

This circuit is mounted on the front etched-circuit board of the DI-4 and functions to extinguish the pilot light in front of the DI-4, if the reference signal is present but the oscillator fails to lock. This function is accomplished by sensing for the presence of ac on the oscillator control line. If ac is present, this implies that either the oscillator is not locked or the phase-lock loop is self-oscillating, either condition being a malfunction. Ac amplifier Q301 will amplify any ac present on the oscillator control line. If any ac is present, it is detected by CR301 and CR302. This changes the bias on Q302, driving Q302 out of conduction. If this occurs, the voltage on the lamp-control pin drops to zero and the lamp-control transistor on the chassis lamp-panel assembly cuts off and extinguishes the lamp. (See Sections BA and BB on the chassis for discussion of the operation of these circuits.)

SECTION DC-3

SERVICE AND MAINTENANCE

DC-3.1 INTRODUCTION.

If the system fault-localization procedure of Section 5 of the front portion of the manual indicates possible malfunction of the DI-4 unit, the most positive verification of this suspicion is the substitution of another DI-4 unit.

NOTE

DI-1 and RDI-1 units may not be substituted for a DI-4

If this step restores the instrument to normal operation,the defective DI-4 should, if possible, be returned to the General Radio Company for service and repair, especially if it is within the two-year warranty.

Since there is but one DI-4 unit per Type 1163 synthesizer, and since service spares may not be available, it will not always be possible to make the substitution as outlined above. Where this is not possible, selected tests and a few alignment steps may be made in the field. The synthesizer cannot operate without a properly functioning DI-4 module.

CAUTION

Most alignment procedures require the use of special test fixtures and cannot be accomplished in the field.

A thorough knowledge of the principles of operation, and all of the circuit arrangements by which the desired operation is achieved, is essential before DI-4 module service is attempted.

DC-3.2 TEST EQUIPMENT.

Recommended test equipment is listed and described in Table DC-2; equivalent equipment may be substituted.

TABLE DC-2

TEST EQUIPMENT

Function	*Type Recommended*	*Minimal Characteristics*
Electronic Voltmeter (VTVM)	GR 1806 with 1806-P1 probe	2% accuracy; ac and dc capabilities
Dual-Trace Oscilloscope	Tektronix 543 (with C/A plug-in and P6006 10x passive probe)	20 Mc/s, 0.5 V/cm with 8 pF (or less) probe capacitance
Alignment Tool	JFD No. 5284	Insulated soft-tip screwdriver
Sampling Oscilloscope	Tektronix 661 with 4S1 and 5T1A plug-in and P6032 CF probe	1000 Mc/s; high-impedance probe
Digital Counter	GR 1144	Up to 50 Mc/s with 5-place readout
Standard Sweep Frequency Generator	GR 1025	Calibration accuracy – 0.5%

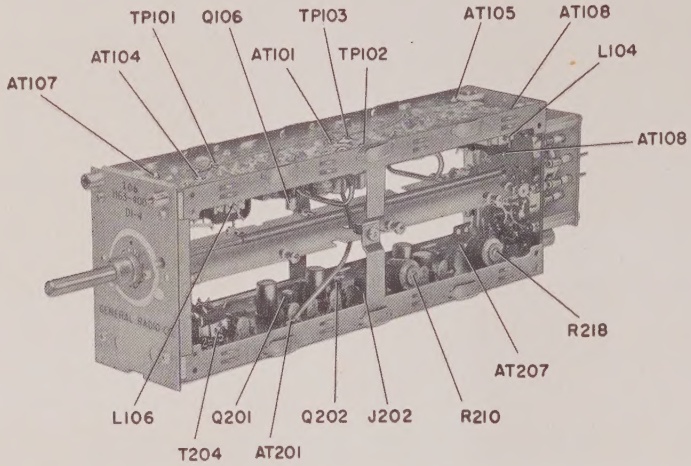


Figure DC-4. Interior of DI-4 module showing test points and secondary adjustment controls.

DC-3.3 TROUBLE ANALYSIS.

CAUTION

Turn power off during set-up changes to avoid accidental short circuits, which can blow F503 in the power-supply module, PS-1, (Section GA).

DC-3.3.1 GENERAL.

Remove the instrument from the cabinet, remove the DI-4 unit and the DI-1 unit in station II. For procedural details refer to Section 5.4.2 (in the front portion of the manual). Release the 6 screws in the sides and slide the cover off the DI-4. Reinstall the unit (less cover) in the chassis and install the spare DI-1 Bridging Unit (supplied) in station II.

Set the DI-4 digit dial to 5, set the DI-1 dials in any position and apply power to the synthesizer.

Refer to Figures DC-4 and DC-5 for the locations of test points and secondary adjustments referred to in procedures that follow. See also Figure DC-14, the over-all schematic diagram.

The most common symptoms of failure within the DI-4 will be the generation of improper frequencies or the failure to give any output whatever. Procedures that follow will give assurance that the difficulty is in the DI-4 module and not in some other unit and will facilitate fault isolation to the detail-part level.

DC-3.3.2 POWER INPUT.

With the VTVM, look for +18 ±0.2 Vdc at AT105 on the top circuit board. If the indication is abnormal, look at AT207 at the bottom circuit board of the DI-4. A level of approximately +17.5 Vdc should be found there and also at the collectors (cases) of Q201, Q202

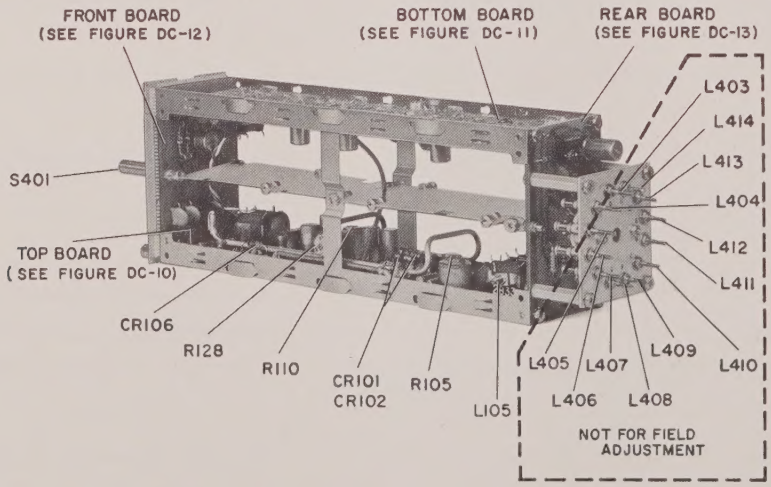
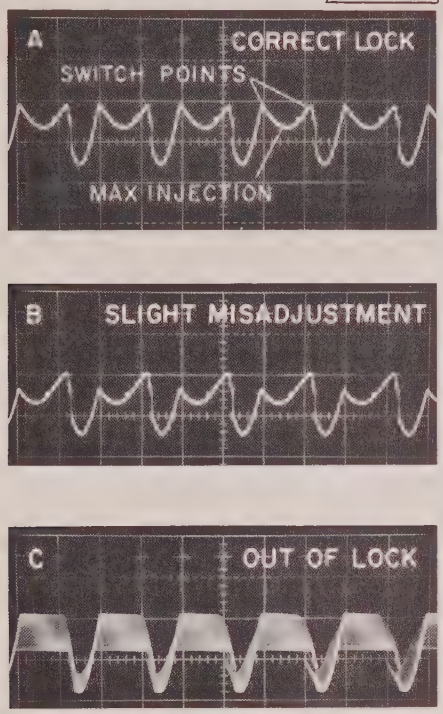


Figure DC-5. Interior of DI-4 module showing test points and secondary adjustment controls (unit inverted). Refer also to Table DC-1. DO NOT CHANGE SETTING OF L403-L414.

1160-G-29



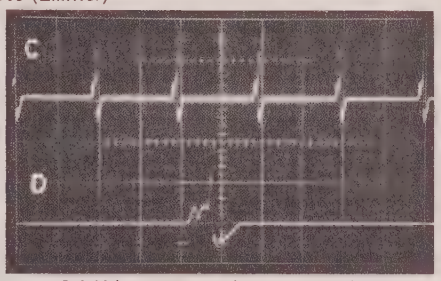
0.5 V/cm 0.5 μs/cm

Figure DC-6. Injection-Locked Oscillator adjustment waveforms shown at TP101 (see Figure DC-4).

Q104 (Collector) 1160-G-30

0.5 V/cm 0.5 μs/cm (upper) 0.1 μs/cm (lower)

Q105 (Emitter)



1.0 V/cm 0.5 μs/cm (upper) 0.1 μs/cm (lower)

Figure DC-7. Typical input and output waveforms for the servo-circuit pulse amplifier (see Figure DC-10).

and Q203 on the bottom board. If the voltage is correct at AT207, but is incorrect elsewhere, the malfunction is in the DI-4. If AT207 indicates an incorrect voltage, check the power supply and chassis-power distribution in the sandwich deck (refer to Sections BB and GA).

DC-3.3.3 1-MC CIRCUITS.

With the oscilloscope, look for the 1-Mc input from the AFS module at J203. If the input signal is missing, distorted, or less than 0.7 V, rms, check the Main Frame (Section BB) and the AFS (Section CA). This test is independent of the settings of the synthesizer front panel controls.

If the 1-Mc input is adequate, observe the waveform at TP101 to check the 1-Mc isolation amplifier, Q204, and the 1-Mc Injection-Locked Oscillator, Q103/Q104. If a full sinewave appears, the oscillator is inoperative; if a half-wave-rectified sinewave appears, the isolation amplifier is not feeding a lock signal to the oscillator.

If necessary, adjust L106 to make the switching points equal in amplitude. Adjust T204 to maximize the injected signal to Q103 and Q104, as in Figure DC-6 (A). Figures DC-6 (B) and (C) show the oscillator out of adjustment.

If the oscillator cannot be brought into lock with L106, measure the frequency of the injection-locked oscillator directly, with the counter at TP101; clip a short lead across AT103 and AT104 (Figure DC-10), to remove the 1-Mc drive to the oscillator for this test. If the frequency is sufficiently removed from its nominal value, the oscillator will not lock.

DC-3.3.4 PULSE CIRCUITS.

The simplest approach to isolate trouble in stages Q103-Q106 is to signal-trace the various waveforms until a defective circuit is located. Figures DC-7 (A and B) show the waveform at the collector of Q104, the input to the pulse amplifier; the output at the emitter of Q105 is shown at Figure DC-7 (C and D).

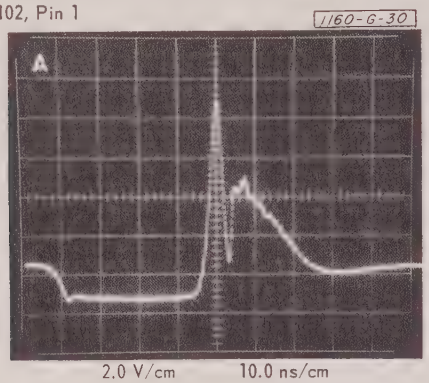
R128 controls the amplitude of the blocking-oscillator pulse, the waveform of which can be observed at the collector of Q106 (case).

CAUTION

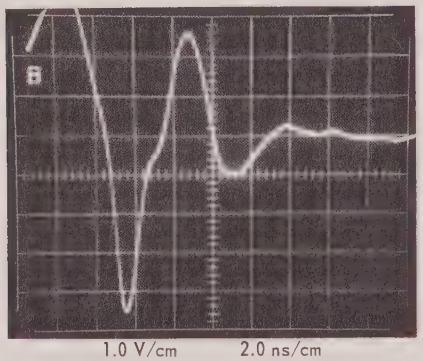
Do not change the setting of R128 unless there is a strong reason to do so, since a change in pulse amplitude can upset the sampler balance.

The sampling oscilloscope is needed for the remainder of the pulse circuits. Figure DC-8 (A) shows the output of the blocking oscillator at pin 1, T102, (use Figure DC-10 to find the test point). Figure DC-8 (B) shows the waveform at the anode of CR106. CR106, a plug-in unit, is selected to give the stored-charge, snap-off characteristics necessary to speed up the blocking-oscillator pulse. Ordinarily this diode should not need to be replaced — the jacks are utilized principally for factory selection of the diodes.

T102, Pin 1



CR106 Anode



TP103 (upper) TP102 (lower)

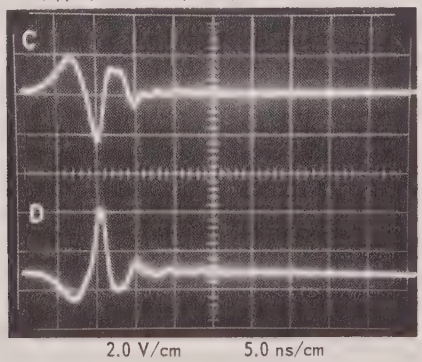


Figure DC-8. Sampling oscilloscope waveforms typical of servo-circuit blocking-oscillator performance.

The waveforms of the remainder of the pulse circuits are checked best when the Digit Oscillator is not running. To stop the oscillator, set the digit dial between steps. Observe the waveforms at TP102 and TP103; see Figure DC-8 (C and D). Diodes CR101 and CR102 must be removed for this test. They are plug-in units in the top circuit board (Figure DC-5). Note carefully the relative positions and polarizations of the diodes on the board prior to removal, so that they can be reinstalled exactly as they were originally.

Switch the digit selector back to one of the dial positions to restore operation of the Digit Oscillator. Reinstall the diodes.

CAUTION

Error in reinstallation of these diodes can adversely affect calibration of the entire module.

DC-3.3.5 RF CIRCUITS.

A rough estimate of the performance of the 39 to 50-Mc sections of the DI-4 module can be made by signal tracing with the oscilloscope and VTVM (see Figure DC-4).

A frequency equal to the digit-output frequency should be found progressively at the following points: AT205 at approximately 0.8 V, rms; J202 (rf Output) 0.3 V, rms (adjustable by R218); and AT201 and AT101 at about 50 - 100 mV, rms, depending on the factory setting of servo control loop-gain, (see Figure DC-11 for test points).

If gain control R210 or other elements in the servo loop become faulty, or misadjusted, the servo-control circuit may oscillate and inhibit normal phase-lock operation. Figure DC-9 is indicative of this symptom, as seen at AT107. This condition cannot be adjusted in the field.

CAUTION

Do not change the setting of R210.

DC-3.3.6 DC AMPLIFIER.

Table DC-3 includes the voltages that should be obtained in the dc amplifier circuits.

DC-3.3.7 NOTCH FILTER.

Remove Q106 to stop the pulse generator. Connect the VTVM (DC mode) to AT108 and adjust R105 to a 6.0 Vdc indication; a right-angle screwdriver can be used for this adjustment.

Connect two 33 kilohm resistors to the base of Q101A, one going to TP101 and the other to TP102,

TABLE DC-3

DC VOLTAGE INDICATIONS

Transistor	*Emitter*	*Base*	*Collector*
Q101A	5.5	6	14.5
Q101B	5.5	6	17.5
Q102	15	14.5	6
Q103	9.2	9.0	0.3
Q104	9.2	9.1	0+
Q105	0+	0+	16.8
Q106	0	-.52	5.5
Q201	11.2	11.9	16.5
Q202	11.5	12.1	17.0
Q203	4.3	5.0	16
Q204	10	10.1	0
Q301	5.5	6.0	11
Q302	.063	.045	.058
Q401	11.5	12.2	17

(across the diodes), to maintain the bias on Q101A. Connect the signal generator, to the base of Q101A, through a 0.01-μF coupling capacitor. Sweep through 1 Mc/s at 0.1 V, rms, and with the VTVM (ac mode), observe the voltage at AT108. The ac voltage output of the amplifier should go through a minimum at 1 Mc/s. If the notch can't be found, the unit must be returned to General Radio for realignment.

DC-3.4 DC VOLTAGE CHECKS.

The procedures in paragraph 3.3 should narrow the search for circuit defects to a circuit function consisting of one, or at the most, a few stages. As a further aid to pinpointing the defective part, the information on dc voltage readings is presented in Table DC-3.

DC-3.5 REPAIRS AND REPLACEMENT.

Replace defective detail parts (with frequency-insensitive functions) to correct deficiencies indicated by the trouble-analysis procedures.

CAUTION

Replacement of frequency-determining parts will require realignment which cannot be accomplished without special test fixtures.

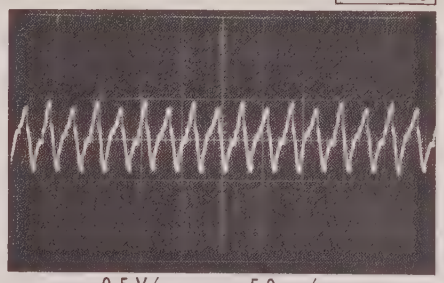


Figure DC-9. Typical waveform at AT107 indicating self-oscillation resulting from an incorrect setting of R210, the Digit Oscillator control-loop gain control.

Figures DC-10 through DC-13 show the physical layout of the parts on the various etched-circuit boards, to speed positive identification. The reference designators for the parts shown on the boards are the same as those used in the over-all schematic diagram, Figure DC-14, and in the parts list at the end of this section.

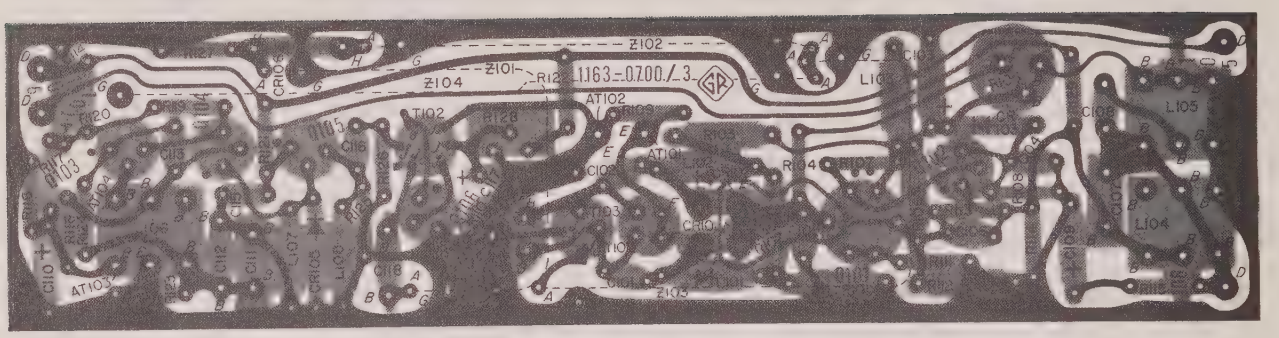


Figure DC-10. Etched-circuit board assembly (top) for DI-4 (P/N 1163-2701).

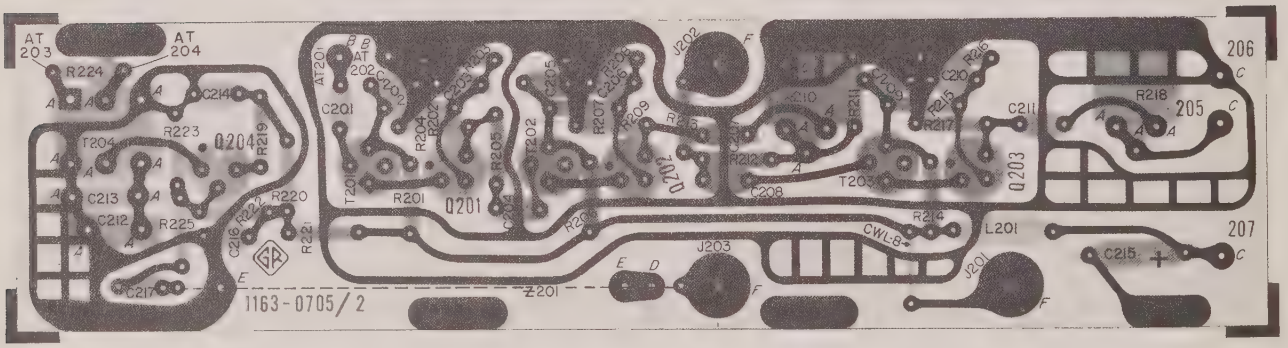


Figure DC-11. Etched-circuit board assembly (bottom) for DI-4 (P/N 1163-2706).

NOTE: The number appearing on the foil side is not the part number. The dot on the foil at the transistor socket indicates the collector lead.

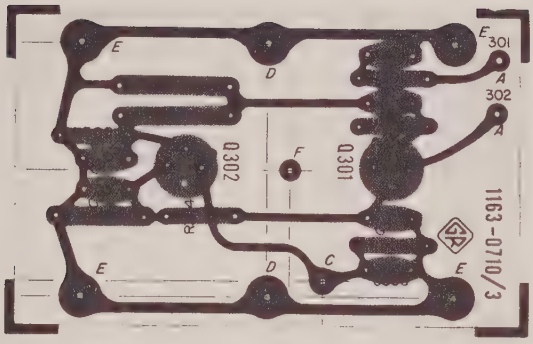


Figure DC-12. Etched-circuit board assembly (front) for DI-4 (P/N 1163-2710).

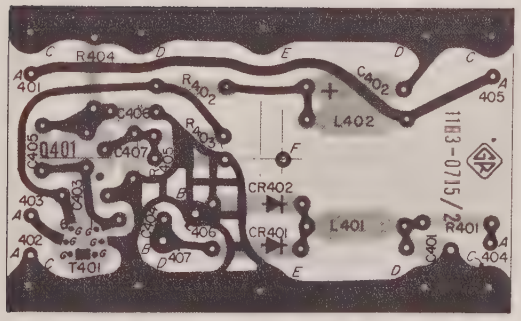


Figure DC-13. Etched-circuit board assembly (rear) for DI-4 (P/N 1163-2716).

NOTE: The number appearing on the foil side is not the part number. The dot on the foil at the transistor socket indicates the collector lead.

PARTS LIST

REF NO	DESCRIPTION	PART NO
	CAPACITORS	
C101	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C102	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C103	Electrolytic, 2.2 μF ±20% 20 V	4450-4500
C104	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C105	Ceramic, 10 pF ±5% 500 V (NPO)	4410-0105
C106	Ceramic, 27 pF ±5% 500 V (N750)	4417-0275
C107	Mica, 243 pF ±1% 500 V	4710-0424
C108	Ceramic, 20 pF ±5% 500 V (N150)	4413-0205
C109	Electrolytic, 2.2 μF ±20% 20 V	4450-4500
C110	Electrolytic, 1.0 μF ±20% 35 V	4450-4300
C111	Mica, 508 pF ±1% 500 V	4710-0579
C112	Ceramic, 91 pF ±5% 300 V (N750)	4417-0915
C113	Ceramic, 10 pF ±5% 500 V (NPO)	4410-0105
C114	Electrolytic, 1.0 μF ±20% 35 V	4450-4300
C115	Ceramic, 0.0047 μF +80-20% 500 V	4450-4300
C116	Ceramic, 470pF ±10% 500 V	4405-1478
C117	Electrolytic, 1.0 μF ±20% 35 V	4450-4300
C118	Ceramic, 0.02 μF +80-20% 50 V	4402-3200
C201	Ceramic, 0.001 μF ±10% 500 V	4405-2108
C202	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C203	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C204	Ceramic, 0.001 μF ±10% 500 V	4405-2108
C205	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C206	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C207	Ceramic, 0.01 μF ±10% 500 V	4405-2108
C208	Ceramic, 0.001 μF ±10% 500 V	4405-2108
C209	Ceramic, 0.01 +80-20% 50 V	4401-3100
C210	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C211	Ceramic, 0.01 μF ±10% 500 V	4405-2108
C212	Mica, 508 pF ±1%	4710-0579
C213	Ceramic, 91 pF ±5% (N750)	4417-0915
C214	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C215	Electrolytic, 2.2 μF ±20% 20 V	4450-4500
C216	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C217	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C301	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C302	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C303	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C304	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C305	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C306	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C401	Ceramic, 20 pF ±5% 500 V (N750)	4417-0205
C402	Electrolytic, 1.0 μF ±20% 35 V	4450-4300
C403	Ceramic, 0.0022 μF +80-20% 500 V	4404-2229
C404	Ceramic, 24 pF ±5% 500 V (N750)	4417-0245
C405	Ceramic, 24 pF ±5% 500 V (N750)	4417-0245
C406	Ceramic, 180 pF ±5% 500 V	4404-1185
C407	Ceramic, 0.0022 μF +80-20% 500 V	4404-2229
	DIODES	
CR101	Semiconductor,	6082-1019
CR102	Semiconductor,	6082-1019
CR103	Semiconductor, type 1N746	6083-1005
CR105	Semiconductor, type 1N191	6082-1008
CR106	Semiconductor, type 1N3604	6082-1001
CR301	Semiconductor, type 1N191	6082-1008
CR302	Semiconductor, type 1N191	6082-1008
CR303	Semiconductor, type TI-56	6082-1016
CR401	Semiconductor, type VA-134	6084-1010
CR402	Semiconductor, type VA-134	6084-1010

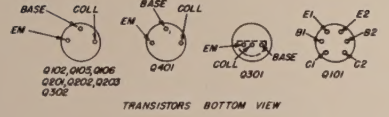
REF NO	DESCRIPTION	PART NO
	INDUCTORS	
L101	Choke, iron core 1.5 μH ±10%	4300-1000
L102	Choke, iron core 1.5 μH ±10%	4300-1000
L103	Choke, iron core 22 μH ±10%	4300-2600
L104	Ferrite cup, adjustable	5000-2832
L105	Ferrite cup, adjustable	5000-2833
L106	Ferrite cup, adjustable	5000-2834
L107	Choke, iron core 22 μH ±10%	4300-2600
L108	Choke, iron core 1.5 μH ±10%	4300-1000
L201	Choke, iron core 22 μH ±10%	4300-2600
L401	Choke, iron core 4.7 μH ±10%	4300-1600
L402	Choke, iron core 22 μH ±10%	4300-2600
L403	Ceramic, iron core, adjustable	1163-2200
L404	Ceramic, iron core, adjustable	1163-2200
L405	Ceramic, iron core, adjustable	1163-2200
L406	Ceramic, iron core, adjustable	1163-2200
L407	Ceramic, iron core, adjustable	1163-2210
L408	Ceramic, iron core, adjustable	1163-2210
L409	Ceramic, iron core, adjustable	1163-2210
L410	Ceramic, iron core, adjustable	1163-2210
L411	Ceramic, iron core, adjustable	1163-2220
L412	Ceramic, iron core, adjustable	1163-2220
L413	Ceramic, iron core, adjustable	1163-2220
L414	Ceramic, iron core, adjustable	1163-2220
	RESISTORS	
R101	Film, 4.99 kΩ ±1% 1/8 W	6250-1499
R102	Film, 2 kΩ ±1% 1/8 W	6250-1200
R103	Film, 11 kΩ ±1% 1/8 W	6250-2110
R104	Composition, 10 MΩ ±5% 1/4 W	6099-6105
R105	Potentiometer, composition 100 kΩ ±20%	6040-1000
R106	Film, 20 kΩ ±1% 1/8 W	6250-2200
R107	Composition, 33 kΩ ±5% 1/4 W	6099-3335
R108	Composition, 3.9 kΩ ±5% 1/4 W	6099-2395
R109	Composition, 47 Ω ±5% 1/4 W	6099-0475
R110	Potentiometer, composition 100 Ω ±20%	6040-0100
R111	Composition, 33 kΩ ±5% 1/4 W	6099-3335
R112	Film, 10 kΩ ±1% 1/8 W	6250-2100
R113	Composition, 22 kΩ ±5% 1/4 W	6099-3225
R114	Composition, 6.8 kΩ ±5% 1/4 W	6099-2685
R115	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R116	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R117	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R118	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R119	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R120	Composition, 100 Ω ±5% 1/4 W	6099-1105
R121	Composition, 330 Ω ±5% 1/4 W	6099-1335
R122	Composition, 680 Ω ±5% 1/4 W	6099-1685
R123	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R124	Composition, 220 Ω ±5% 1/4 W	6099-1225
R125	Composition, 150 Ω ±5% 1/4 W	6099-1155
R126	Composition, 820 Ω ±5% 1/4 W	6099-1825
R127	Composition, 220 Ω ±5% 1/4 W	6099-1225
R128	Potentiometer, wire-wound 2 kΩ ±5%	6053-1105
R129	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R201	Composition, 100 Ω ±5% 1/4 W	6099-1105
R202	Composition, 6.8 kΩ ±5% 1/4 W	6099-2685
R203	Composition, 18 kΩ ±5% 1/4 W	6099-3185
R204	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R205	Composition, 22 Ω ±5% 1/4 W	6099-0225
R206	Composition, 100 Ω ±5% 1/4 W	6099-1105

REF NO	DESCRIPTION	PART NO
	RESISTORS (Cont)	
R207	Composition, 6.8 kΩ ±5% 1/4 W	6099-2685
R208	Composition, 18 kΩ ±5% 1/4 W	6099-3185
R209	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R210	Potentiometer, composition 100 Ω ±20%	6040-0100
R211	Composition, 12 Ω ±5% 1/4 W	6099-0125
R212	Composition, 100 Ω ±5% 1/4 W	6099-1105
R213	Composition, 51 Ω ±5% 1/4 W	6099-0515
R214	Composition, 100 Ω ±5% 1/4 W	6099-1105
R215	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R216	Composition, 2.2 kΩ ±5% 1/4 W	6099-2225
R217	Composition, 270 Ω ±5% 1/4 W	6099-1275
R218	Potentiometer, composition 100 Ω ±20%	6040-0100
R219	Composition, 220 Ω ±5% 1/4 W	6099-1225
R220	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R221	Composition, 100 Ω ±5% 1/4 W	6099-1105
R222	Composition, 8.2 kΩ ±5% 1/4 W	6099-2825
R223	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R224	Composition, 33 Ω ±5% 1/4 W	6099-0335
R225	Composition, 470 Ω ±5% 1/4 W	6099-1475
R301	Composition, 220 Ω ±5% 1/4 W	6099-1225
R302	Composition, 820 Ω ±5% 1/4 W	6099-1825
R304	Composition, 680 Ω ±5% 1/4 W	6099-1685
R305	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R306	Composition, 330 Ω ±5% 1/4 W	6099-1335
R401	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R402	Composition, 150 Ω ±5% 1/4 W	6099-1155
R403	Composition, 33 kΩ ±5% 1/4 W	6099-3335
R404	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R405	Composition, 150 kΩ ±5% 1/4 W	6099-4155
	TRANSISTORS	
Q101	Type 2N2453	8210-1046
Q102	Type 2N3250	8210-1089
Q103	Type 2N3638	8210-1096
Q104	Type 2N3638	8210-1096
Q105	Type 2N708	8210-3089
	TRANSISTORS (Cont)	
Q106	Type 2N2369	8210-1052
Q201	Type 2N708	8210-3089
Q202	Type 2N708	8210-3089
Q203	Type 2N2218	8210-1028
Q204	Type 2N3638	8210-1096
Q301	Type SE4002	8210-1077
Q302	Type 2N1305	8210-1305
Q401	Type 2N918	8210-1066
	MISCELLANEOUS	
Z101	Delay line, rigid-wall coaxial, miniature	1163-0201
Z102	Delay line, rigid-wall coaxial, miniature	1163-0202
Z103	Delay line, rigid-wall coaxial, miniature	1163-0203
Z104	Delay line, rigid-wall coaxial, miniature	1163-0204
Z201	Delay line, rigid-wall coaxial, miniature	1163-0200
J201	JACK, etched-circuit, eyelet-type	1160-6110
J202	JACK, etched-circuit, eyelet-type	1160-6110
J203	JACK, etched-circuit, eyelet-type	1160-6110
S401	SWITCH, rotary wafer	7890-4300
T101	TRANSFORMER, video, interstage	5000-2403
T102	TRANSFORMER, video, interstage	5000-2601
T103	TRANSFORMER, video, interstage	5000-2403
T201	TRANSFORMER, video, interstage	5000-2401
T202	TRANSFORMER, video, interstage	5000-2401
T203	TRANSFORMER, video, interstage	5000-2401
T204	TRANSFORMER, ferrite cup, adjustable	5000-2835
T401	TRANSFORMER, ferrite cup, adjustable	5000-2602
	CIRCUIT BOARD – ASSEMBLIES	
	Top circuit board	1163-2701
	Bottom circuit board	1163-2706
	Front circuit board	1163-2710
	Rear circuit board	1163-2716

Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/4 WATT.
5. RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM.
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS. LESS THAN ONE IN MICROFARADS.
7. KNOB CONTROL.
8. SCREWDRIVER CONTROL.
9. AT ANCHOR TERMINAL.
10. TP TEST POINT.



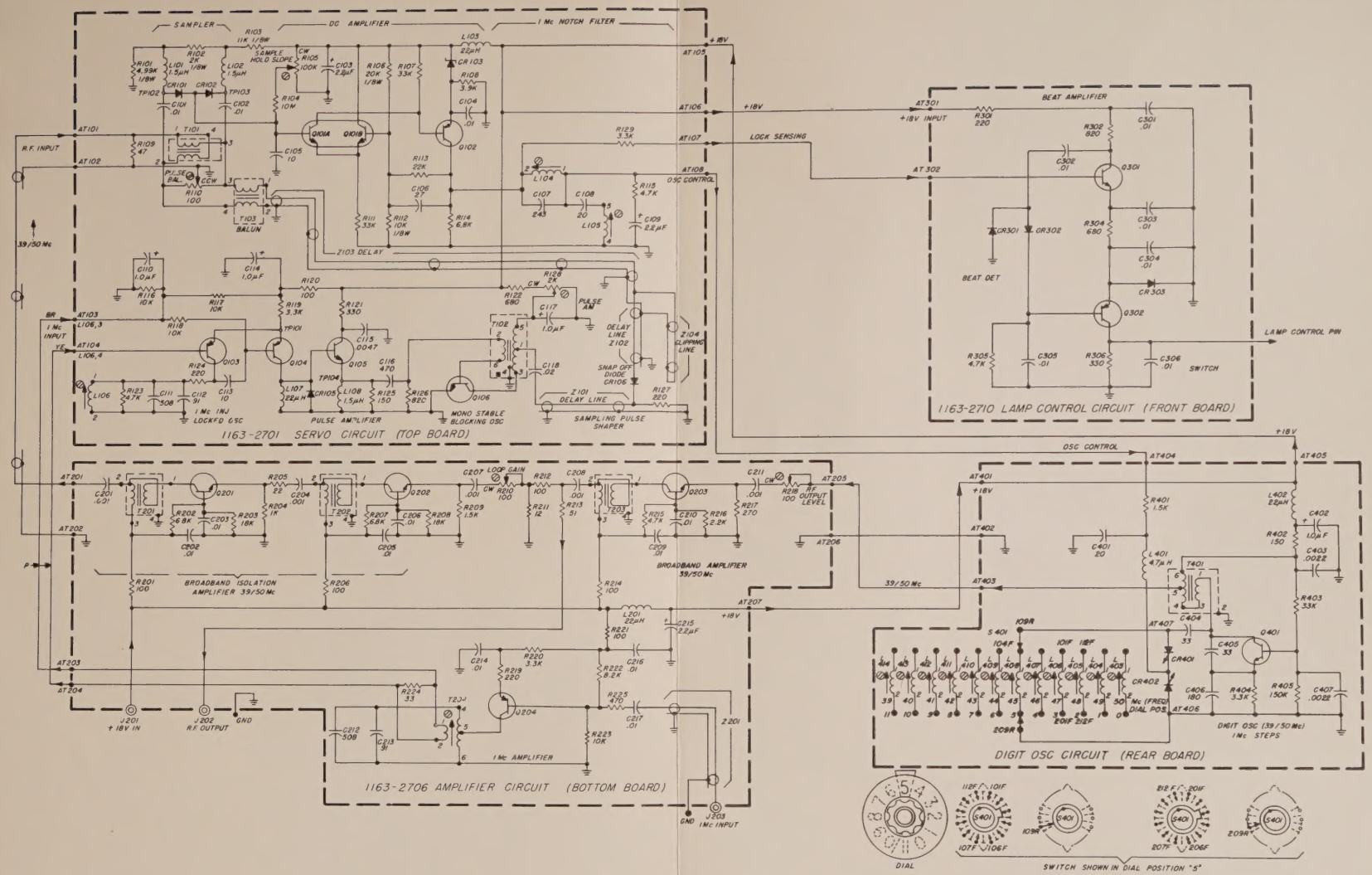


Figure DC-14. Over-all schematic diagram for the Digit-Insertion Unit DI-4 (P/N 1163-4000).

91660